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DISTRACTION EFFECTS AND STIMULUS GENERALIZATION[1]

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In three different experiments, 84 Ss were trained on a multiplication task under identical stimulus conditions. Then, on the test trials, stimulus change was introduced either in an irrelevant background tone (distraction paradigm), in the size of the critical stimulus digits (stimulus generalization paradigm), or in both these aspects at the same time. In all three cases, the decrement in speed of response was found to increase significantly as a function of the degree of stimulus change and to decrease with increasing familiarity with the test stimuli. Records of changes in skin conductance obtained simultaneously gave roughly corresponding results. The similarity of the findings in the different paradigms suggests an interpretation of both distraction and stimulus generalization phenomena in terms of one set of explanatory concepts, interference from "novelty" reactions.

In both distraction and stimulus generalization experiments, the investigator studies the change in performance brought about by an unannounced alteration in certain stimulus conditions from the control (or training) to the test trials. It has been suggested (Bindra, 1961; Williams, 1963) that results obtained in some of these experiments may be the outcome of the interference from "novelty reactions" evoked by unexpected stimulus change. Thus, to a certain extent, the two sets of phenomena may have a common explanation. The present study examines this idea. Certain features of stimulus generalization experiments were introduced into the typical paradigm of distraction experiments so as to render the two paradigms comparable.

The effects on performance of variations in a background stimulus aspect of the experimental situation (distraction paradigm) were compared with those of variations in the critical or training stimulus aspect (stimulus generalization paradigm), as well as with those resulting from variations in both these aspects at the same time. Following the procedure of generalization experiments, the stimulus variations

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were carefully controlled and systematically varied along defined dimensions in the three conditions. Also in the three conditions, the change in performance was studied not only in relation to degree of stimulus change (stimulus generalization paradigm) but also as a function of the repeated presentation of the stimulus change (distraction paradigm). By thus obtaining comparable data from the two paradigms, it was hoped to determine whether the same descriptive concepts could be applied to the two phenomena; in other words, whether the dichotomy of "stimulus change in a critical training dimension" vs. "stimulus change in a background dimension" is one of any particular significance in formulating a general theory of the effects of stimulus change. An answer to this is of some importance in the examination of various views concerning the nature of stimulus generalization, particularly the "novelty reactions" view (Bindra, 1961).

The general plan of this study involved training subjects on a multiplication task under certain stimulus conditions, and testing their performance on the same task under three different conditions: (1) when a background aspect of the training situation, namely the frequency of an irrelevant tone, was altered (Experiment 1); (2) when an aspect of the critical stimulus, namely the size of the digits, was varied (Experiment 2); and (3) when both these aspects were varied at the same time (Experiment 3). The experimental variable, stimulus change, was represented by four different values in the first two experiments, and by three different values in the third. In addition to response time, which served as the measure of performance on the multiplication task, a rough index of "novelty reaction" evoked by the stimulus change was obtained by recording skin conductance (GSR).

METHOD

Subjects. High school and college students served as subjects in this study. There were 84 subjects in all, 24 in Experiment 1, 24 in Experiment 2, and 36 in Experiment 3.

Task and apparatus. S sat about 36 in. in front of a ground-glass screen. His task was to multiply by seven each of a series of digits presented to him on the screen and to record each answer on response keys as rapidly as possible. A row of 10 response keys, numbered from 0 to 9, and set about 1¼ in. apart, was placed in front of the subject. To register each answer, S had to depress two of these keys, one after another, with the index finger of his preferred hand. Thus, for the answer 63 (where the exposed digit was 9), the subject had to press down first Key No. 6 and then Key No. 3. To insure that S would always start from the same position, he was required to keep Key No. 0 depressed between the exposures of successive stimulus digits. S's answers were recorded on a ten-pen chart (Esterline-Angus Model AW Operation Event Recorder) driven at a uniform speed. Response time of each answer could be read from the chart.

Digits to be multiplied were presented by a projector placed about three feet behind the screen. The digits varied from 2 to 9, and were exposed separately for 0.5 sec., at the rate of one digit every 3.5 sec. Simultaneously with the presentation of each digit, a pure tone of a specified frequency was presented to S through earphones; the tone remained on for the duration of each digit exposure.

An Esterline-Angus (Model AW) DC Microammeter was used to record S's skin conductance. The electrodes used consisted of two small zinc cups, ¼ in. deep by ¼ in. in diameter. These cups were filled with pieces of sponge soaked in saline solution. Both the conductance recorder and the recorder used for recording S's answers were connected to a time circuit in such a manner that the time of each digit presentation was indicated on both the charts; this served as a guide in scoring. Except for the set of response keys in front of the subject, all the other pieces of equipment were placed behind the ground-glass screen, out of S's view.

Procedure. Electrodes were applied to the tips of the index and the middle finger of the non-preferred hand. A four-minute rest period was allowed to elapse between the application of the electrodes and the next step in the procedure.

In Experiments 1 and 2, Ss were required to multiply (by seven) five consecutive series of 30 digits each; in Experiment 3, four consecutive series were presented. Each presentation of a digit may be considered a trial. A two-minute rest period was given after every series. During the first series, the preliminary training series, a pure tone of 1850 cps and of an intensity level of 90 db was delivered to S's ears simultaneously with each digit exposure. This tone was sufficiently loud to screen out effectively any sound from the apparatus. The size of each digit on the screen during training was 30 mm.

The experimental procedure employed during the training series was identical in the three experiments. The purpose of this preliminary training series was to have S become familiar with the procedure and master the task. After the preliminary training series, S was tested on the same task in the course of four test series in Experiments 1 and 2, and three test series in Experiment 3, but under different conditions in the three experiments.

In Experiment 1, the frequency of the tone, a background aspect of the training situation, was suddenly changed from 1850 cps, the frequency used during the preliminary training series, to either 1400, 1000, 670 or 380 cps on the test trials. These frequencies were selected as representing roughly equal steps of 250 mels between any two adjacent tones. Intensity was differentially increased on test tones 670 and 380 cps to equate for apparent loudness. In Experiment 2, the frequency of the background tone remained constant (1850 cps),

but the size of the stimulus digits, the task stimuli, was altered from 30 mm., the size during the preliminary training series, to either 50, 85, 112 or 145 mm. on the test trials. In Experiment 3, both the frequency of the background tone and the size of the task stimuli were simultaneously varied from 1850 cps and 30 mm. to either 1400 cps and 50 mm., 1000 cps and 85 mm., or 670 cps and 112 mm. on the test trials. In each test series, one test condition was introduced on five trials (from Trial 16 to Trial 20); on Trial 21, the test stimulus was changed back to the control stimulus. The effects of each test condition were examined in a different series, each S being tested on four test stimuli in Experiments 1 and 2, and on three test-stimulus combinations in Experiment 3. A permutational order of presentation of the test stimuli was followed across Ss in each of the three experiments.

In Experiment 2, any change in performance from the control to the test trials might have resulted from differential difficulty in reading exposed digits of different sizes. This possibility was checked by conducting a subsidiary experiment to investigate the readability of the four digit-sizes. The results showed that the test-digit sizes used in Experiment 2 did not differ as far as ease of reading was concerned, as judged by response latency.

In Experiment 3, three different degrees of stimulus change were used instead of four as in Experiments 1 and 2. As the interest here lay in the influence of order of presentation of the test stimuli on the test results (order effect), only three test stimuli were used, thus reducing the number of permutations to a manageable number.

Scoring. In the three experiments, the scores computed were for Trials 13 to 18 of each test series. Since the test stimuli were introduced on Trial 16 in every test series, Trials 13, 14 and 15 will be referred to as pre-change trials, and Trials 16, 17 and 18 as post-change trials. Pre-change and post-change trials were scored for response time and change in skin conductance. Response time here is the time that elapsed between the onset of the exposure of a digit on the screen and the depression of the second key corresponding to S's answer. The digits 3, 7 and 9, that were successively presented on the pre-change trials, were also used on the post-change trials, but in a different order (7, 3 and 9). This arrangement made it possible to compare the response time on each post-change trial with that on a pre-change trial requiring an identical answer. Response time was measured on the chart by means of a calibrated ruler. Conductance change brought about by stimulus variation under the test conditions of each experiment was used as a rough index of "novelty reactions." As conductance change (GSR) has a long latency, two scores only could be obtained for each test series, the highest conductance (in micromhos) registered during the three pre-change trials, and the highest conductance obtained during the three post-change trials.

Performance change and conductance change were defined as the difference between the pre-change and the post-change scores, pre-change scores being subtracted from post-change scores. Thus, a positive difference indicated a response decrement (i.e., increase in response time) or an increase in conductance brought about by the change in stimulation.

RESULTS

This study was concerned with two main effects: (1) a *stimulus-change effect,* based on the extent of difference between the training and the test stimuli; and (2) an *adaptation effect* through test trials and through test series, based on increasing familiarity with the test stimuli and the experimental procedure.

The stimulus-change effect. This effect can be clearly seen in Figs. 1 and 2, where mean changes in response time (Fig. 1) and in conductance (Fig. 2) have been plotted as a function of test tones (Experiment 1), of test-digit sizes (Experiment 2), and of tone and digit-size combinations (Experiment 3) for each test series. In these figures, the increase in response time (Fig. 1) appears to be systematically related to the degree of stimulus change only in Test Series I in the three experiments, whereas the increase in conductance (Fig. 2) appears to be proportional to the degree of stimulus change in Test Series I of Experiment I and in Test Series I, II and III of Experiment 3.

The response-time and the conductance changes of each test series of the three experiments were analyzed for trend using the method of orthogonal polynomials (parametric trend test) as described by Edwards (1960). This analysis revealed that the test tones, the test-digit sizes, as well as the tone and digit-size combinations had significant differential effects on both response time ($p<.05$ in Test Series I of Experiments 1 and 2, and $p<.01$ in Test Series I of Experiment 3), and on conductance ($p<.05$ in Test Series I of Experiment 1, and $p<.01$ in Test Series I and II of Experiment 3). In this analysis, none of the deviation components was significant. This shows that the linear regression line was a good fit to the treatment means in all cases. The significant linear trend indicates that the response-time and conductance means increase as a direct function of the distance between the training and the test stimuli.

Increases in response time and in conductance at each test point in Test Series I of Experiment 3 were expected to be larger than those obtained in Test Series I of Experiment 1 or 2, due to simultaneous manipulation of two stimulus dimensions on the test trials. In fact some changes were, but only slightly. These changes were analyzed by means of the t-test to evaluate their significance. Only one difference was found to be significant ($p<.05$), that at test point 3 on the con-

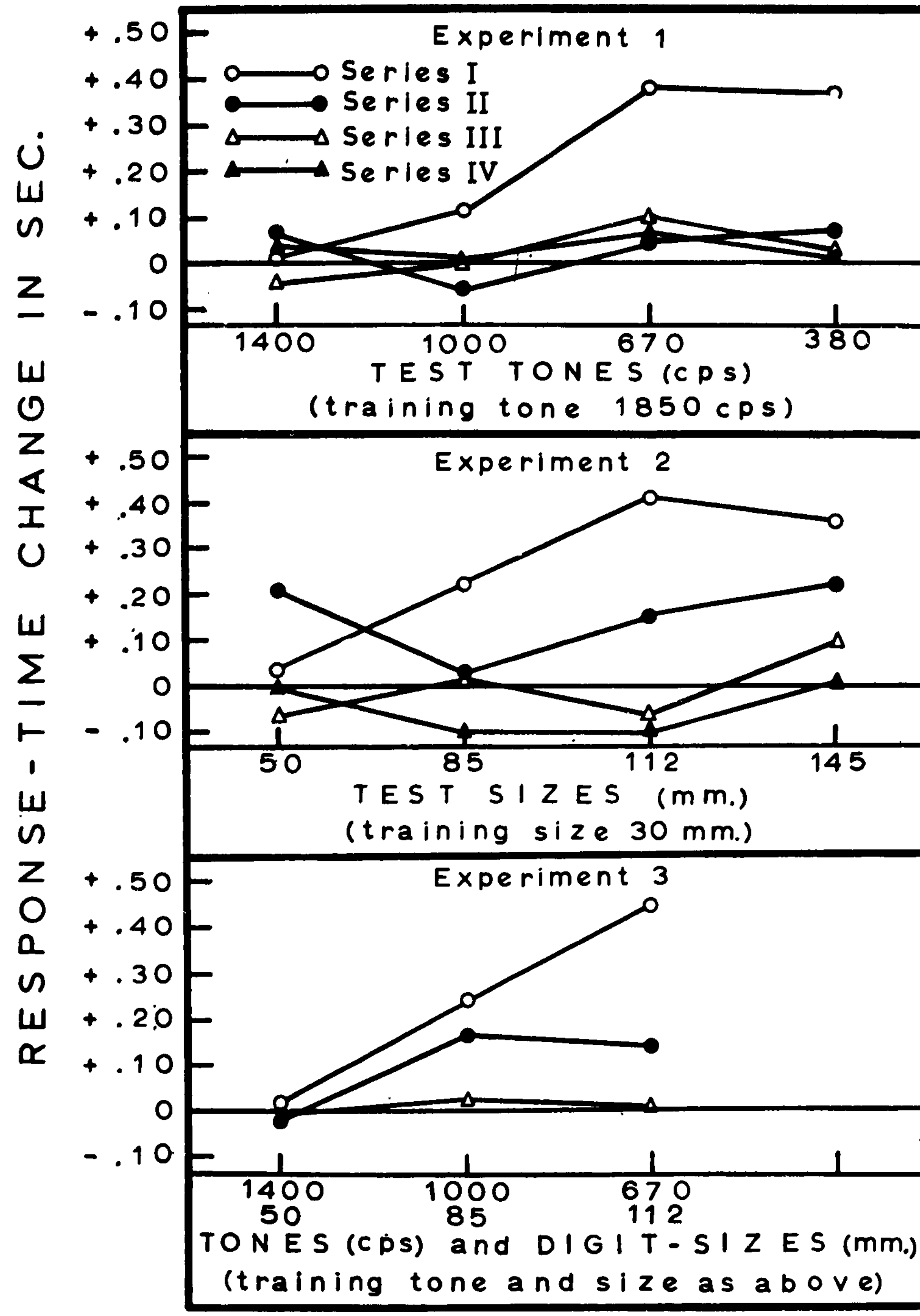

Fig. 1. Differences in response time between pre-change and post-change trials as a function of test series and test stimuli. Each point is the mean of the difference scores for 6 Ss in Experiments 1 and 2, and for 12 Ss in Experiment 3.

ductance data. This means that the autonomic reaction, but not the disruption of performance, was greater when stimulus change was

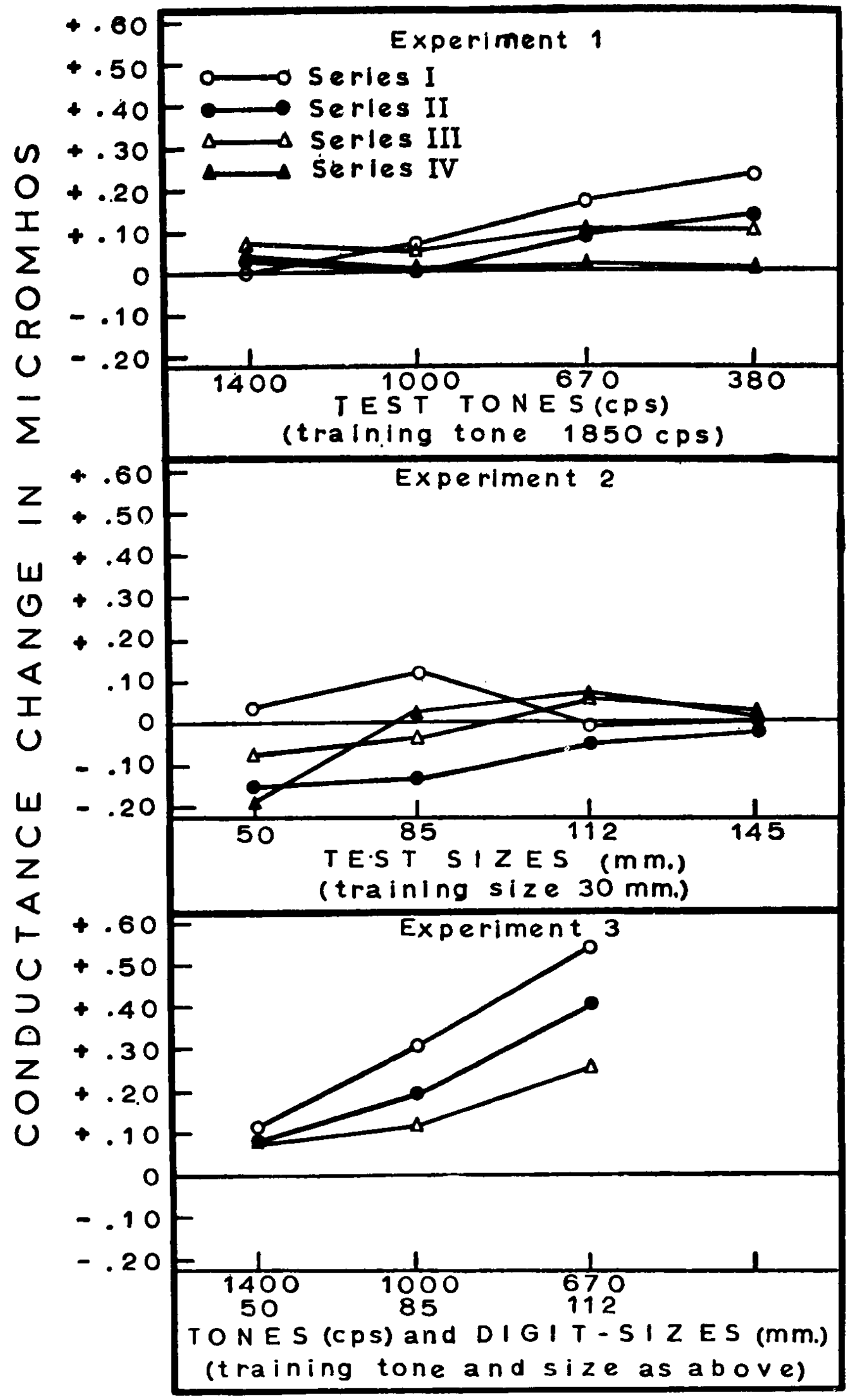

Fig. 2. Differences in conductance between pre-change and post-change scores as a function of test series and test stimuli. Each point is the mean of the difference scores for 6 Ss in Experiments 1 and 2, and 12 Ss in Experiment 3.

simultaneously introduced in two stimulus dimensions than when it was introduced in one only.

The adaptation effect. For the analysis of the adaptation effect through post-change trials and through the successive test series, differences between pre-change and post-change response times for Trials 1, 2 and 3 were computed separately. For each experiment, the difference scores for the different test stimuli were combined in each test series. These data are plotted as a function of test trials and test series in Fig. 3.

In this figure, the course of declining increments in response time observed both through test trials within test series and through the test series, for each trial taken separately, clearly indicates an adaptation to stimulus change in the three experiments. Three-way analyses of variance were conducted on these difference scores to test the significance of the change in response decrement, that is, of the adaptation effects observed (test trials $\times$ test series $\times$ subjects, Experiments 1 and 2, McNemar, 1962, Case XII; and test trials $\times$ test series $\times$ orders, Experiment 3, Case I, Winer, 1962, p. 319). A different statistical test was used in Experiment 3 to permit an analysis of the influence of order of presentation of the test stimuli (order effect) on the test results. The analyses of variance revealed that both the test trials and test series effects were significant ($p<.01$ in both cases) when tone was varied (Experiment 1) and when tone and digit-size were simultaneously altered (Experiment 3), but when digit size was manipulated (Experiment 2) the test series effect only was significant ($p<.01$). No significant order effect was observed in Experiment 3. Since the test stimuli used in Experiment 3 were combinations of the test stimuli (tone and digit-size) that were used in Experiments 1 and 2, it is reasonable to suppose that in Experiments 1 and 2 also, no differential adaptation effects resulted from different orders of presentation of the test stimuli. Thus, we may conclude that the differential decrease in response-time increments through the test series in the three experiments and through the test trials in Experiments 1 and 3 resulted from increasing familiarity with the test stimuli through successive exposure to them, and is not attributable to any order effect.

As for the conductance measure, no significant adaptation or order effect was found to occur in any of the three experiments.

DISCUSSION

The main findings in this study are relevant to an examination of various views concerning the nature of stimulus generalization.

The stimulus-change effects obtained in the present study would, of course, be predicted from the process of primary stimulus generali-

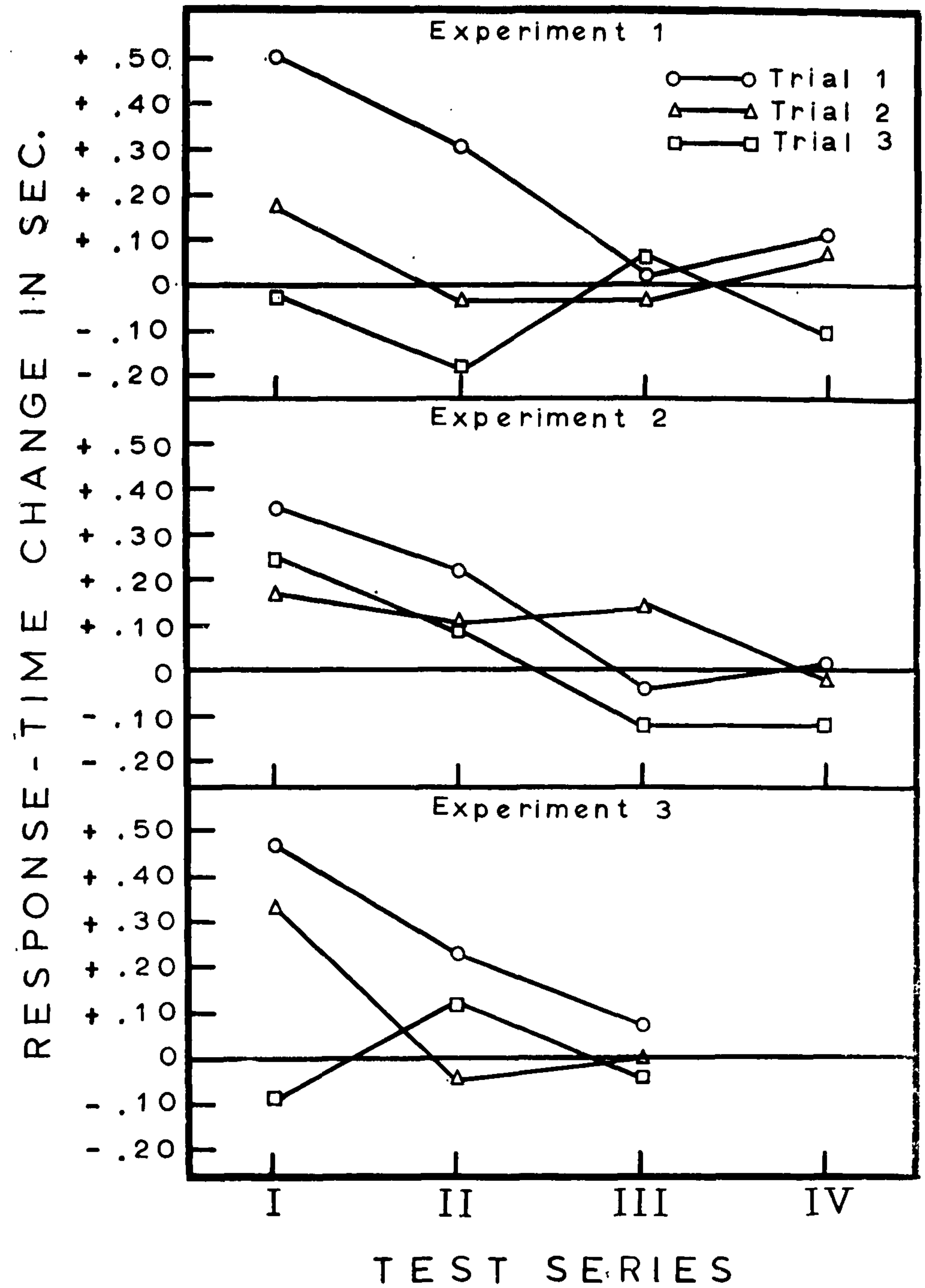

Fig. 3. Differences in response time between pre-change and post-change trials as a function of Trials (1, 2 and 3) and of Test Series (I, II, III and IV). Each point is the mean of the differences for 24 Ss in Experiments 1 and 2, and for 36 Ss in Experiment 3.

zation postulated by Pavlov (1927) and Hull (1943), though it has been customary to look upon such gradients as resulting from stimulus varia-

tions in critical or training stimuli only. In the present study they were obtained from changes in both the critical and the background stimuli. The view of Estes (1950) and Estes and Burke (1953), that the response probability in the test situation depends upon the proportion of conditioned-stimulus elements shared by the control and the test situations, as well as Razran's (1949) hypothesis that the test response is determined by how similar to the control stimulus S judges the test stimulus to be, would also predict progressively greater response decrement (increase in response time) with increasing distance between the control and test stimuli. However, in none of the above theories is the role of adaptation explicitly recognized. The adaptation effects must contribute in an important way to the results of experiments on stimulus generalization (see, e.g., Williams, 1963) especially where the results of several test trials are grouped together.

Bindra's (1959, 1961) interpretation of stimulus-change-induced response decrement attributes it to the interference caused by the occurrence of novelty reactions. The frequency and duration of the occurrence of novelty reactions is known to depend directly upon the amount of stimulus change (Bindra & Spinner, 1958), and inversely on the degree of the subject's familiarity with that change (Claus & Bindra, 1960). This view suggests that response decrement under test conditions would depend upon the type of novelty reactions evoked by the stimulus change and by their frequency and duration (Bindra, 1961). Bindra's hypothesis also implies that with increasing familiarity with the test stimuli, there would be a reduction in the occurrence of novelty reactions. This view makes no distinction between the gradients of distraction (Experiment 1) and the gradients of stimulus generalization (Experiment 2).

The present results show clearly that controlled stimulus changes in the frequency of a background tone (distraction paradigm), in the size of the task stimuli (stimulus generalization paradigm), and in both these aspects at the same time, produced similar decrements in the performance of a conceptual-motor task. Increase in response time was significantly related to the *degree* of stimulus change in Test Series I in all the three experiments. A clear-cut *adaptation* to stimulus change was also found to occur through the test series in the three experiments. Increase in skin conductance, a rough index of novelty value of stimulus change, was correlated to the amount of stimulus change in Test Series I of Experiment 1, and in Test Series I and II in Experiment 3. Thus the main effects predicted by the novelty reactions interpretation were found to occur in both the distraction and the stimulus generalization paradigms.

The response-time results of the three experiments differed in one detail only. Adaptation to stimulus change occurred through the test trials, in addition to adaptation through the test series, when tone (Ex-

periment 1) or tone and digit-size (Experiment 3) were varied, but when digit-size alone (Experiment 2) was altered, the adaptation effect was observed only through the test series.

This discrepancy may possibly reflect the fact that the tone was a background stimulus and digit-size an aspect of the critical stimulus. However, another explanation is equally plausible. Since tone and digit-size variations acted on different sense modalities, they may well have constituted different types of novelty, and may thus have elicited different types of novelty reactions followed by different rates of adaptation. For example, it may be argued that change in tone frequency produced a mild startle reaction, but the change in the size of stimulus digits evoked visual exploration. Spontaneous comments from the subjects who served in these experiments appear to support this differential novelty-reaction hypothesis. "I jumped when you changed the tone" or "I had to look twice when big digits appeared on the screen" were the usual comments. Now, if we assume that the motor component of the startle response is completed in about half a second (Landis and Hunt, 1939), while visual exploration, once initiated, may continue for several seconds, we can account for the lack of a significant adaptation effect through trials within a series in the case of visual change.

This differential novelty-reaction hypothesis is further supported by the significant conductance increase obtained in Experiments 1 and 3 and the absence of consistent conductance changes when size was varied in Experiment 2. The latter finding might also be accounted for by the greater sensitivity of the autonomic reaction to auditory than to visual stimuli (Davis, 1930). Unfortunately, the design of this preliminary experiment permits only the formulation of these hypotheses regarding the differential effects of visual and auditory stimuli.

It is to be noted that the response time data of the three experiments show a pattern of adaptation to novel stimuli that is quite similar to the one frequently found in animal studies (e.g., Berlyne, 1955; Claus & Bindra, 1960). In Fig. 3, response time can be observed to decrease through test trials within a test series, especially in Experiments 1 and 3, but in most cases there is an increase in response time from the last trial (Trial 3) of one test series to the first trial (Trial 1) of the following series. The initial increase in response time observed when a test stimulus was introduced in Test Series I might be attributed to interference from novelty reactions evoked by the sudden presentation of the test stimulus, and the decrease in response decrement observed on Trials 2 and 3 to increasing familiarity. When the subject was confronted with the test stimuli in successive test series (Test Series II, III and IV) the increase in response time from the last trial of one test series to the first trial of a following series would be expected because the interpolated retraining trials with the original training stimulus would tend to increase novelty reactions again on the next introduction of the test stimulus. However, the incidence of the novelty reactions evoked by

the test stimuli would decrease within and over test series due to increased familiarity with the total test procedure, as has been shown by Bindra & Claus (1960).

In short, the observed findings of the present study are best interpreted in terms of interference from novelty reactions rather than in terms of differential generation of training effects (Pavlov, Hull), of common-elements (Estes and Burke) or relational categorization (Razran). In addition, the novelty-reactions view suggests a way of interpreting the phenomena of both stimulus generalization and distraction effects in terms of one set of explanatory concepts.

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